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Hessian Fly Biotype Distribution, Resistant Wheat Varieties and Control Practices In Hard Red Winter Wheat[1]

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Introduction

The Hessian fly *Mayetiola destructor* (Say) was introduced into the United States in the late 1700's. The common name Hessian fly derived from the belief that it was imported in the straw mattresses of Hessian soldiers or in the bedding and fodder for their horses. Subsequent introductions of the insect, however, are known. The Pacific Northwest became infested in the mid-1800's, and the Mennonite immigrants undoubtedly brought the fly from the Hard Red Winter Wheat area of Europe to the central Great Plains states.

The fly was first noticed as a serious pest of wheat in several eastern Kansas counties in 1878, after being observed in Missouri a few years earlier. It spread westward across Kansas and by 1920 was considered a serious pest in all wheat growing areas of Kansas. Approximate dates showing the rapid spread of fly across Kansas are illustrated in figure 1 (*6*, *8*).[3] It spread across Nebraska during the same period.

In the mid-1930's at least two biotypes (races of the fly) were recognized, as were different reactions to the fly by different wheat varieties. Genetic studies have shown three main biotypes of the fly in the area covered by this report—the Great Plains race and races A and B. (Throughout this report the terms race and biotype are used synonymously.) Fly races are distinguished by the ability or inability of the fly to infest certain wheat varieties that have specific genes for resistance. The flies are not considered separate entities but merely individuals of a highly heterogeneous insect population whose members express different biological abilities that depend on the genetic compositions of individual insects and their host plants.

History of Resistance

When the Hessian fly first became a serious pest of wheat in Eastern United States about 1790, and earlier in Europe, farmers noticed that some wheat varieties were damaged less than others. Recommendations were made to grow certain wheat varieties; early selections were made. Lack of technical knowledge of wheat breeding and genetics precluded any concentrated breeding program to develop a resistant wheat; so in the 1920's wheat breeders began hand pollination to create new wheat varieties. Breeding for Hessian fly resistance did not get underway until the 1930's.

Farmers also realized that some wheats were resistant or less damaged in one area than in another. Often the areas were not far apart, and the reason for the selective damage was not understood. Painter (*9*) reported that different biological races or biotypes of the fly were the cause. He presented evidence to prove two fly races existed and suggested that Kansas probably had three fly races. Later studies show that he was working with three races: Great Plains race, race A, and race B.

In 1930 eastern Kansas was considered a soft wheat area. Many of the soft wheats are resistant to Great Plains and race A flies but are susceptible to race B flies. Field plot infestations and

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[3]Italic numbers in parentheses refer to Literature Cited, p. 7.

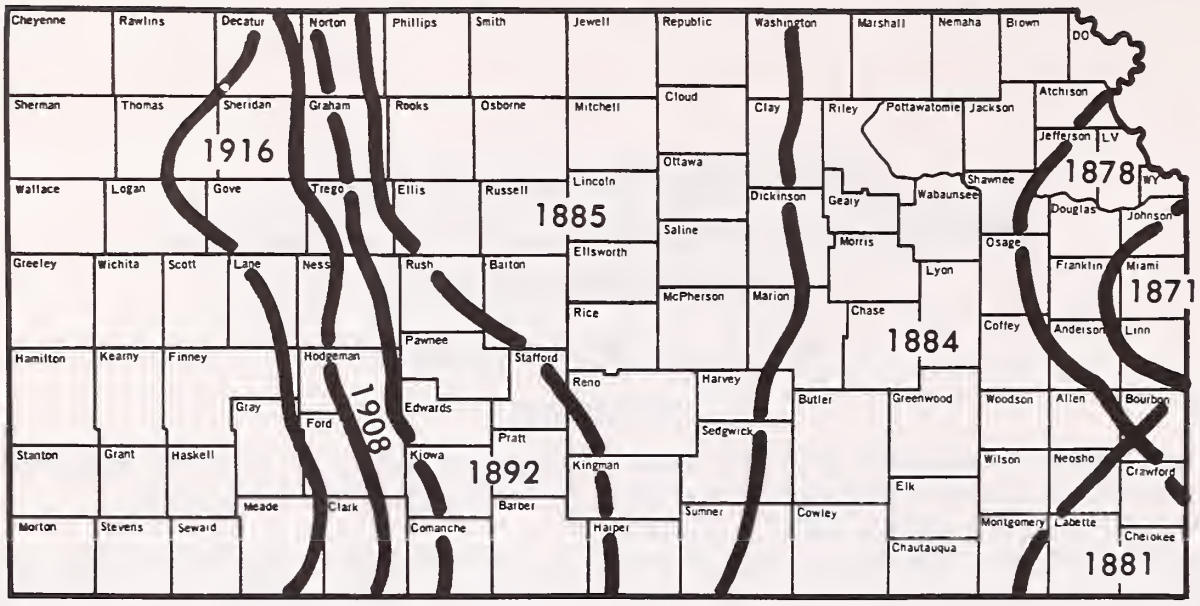

FIGURE 1.—Westward progression of the Hessian fly across Kansas.
(Determined by Headlee and Parker in 1919 and Parks in 1917)

even some of Painter's (*9*) greenhouse tests showed that race B flies were more prevalent, particularly in southeastern Kansas (fig. 2). The occurrence of this race of fly is easily understood because any time selective pressure (resistant wheats) is placed on the fly population more virulent races may develop.

Another factor may have been that the Great Plains race, introduced by Mennonite settlers, was spreading eastward from central Kansas. Because the Great Plains race of fly is genetically dominant (*1, 3*), it is expected to be the prevalent race in areas where selective pressure has not been applied. Figure 2 gives the present distribution of the fly races in the central Hard Red Winter Wheat area.

TABLE 1.—*Indicate data on Hessian Fly resistant wheat varieties developed for the Hard Red Winter Wheat area of the United States*

Variety	CI[1] number	Year released	Source	Type of resistance[2]	Area of adaptability[3] Kansas	Nebraska	Missouri
Pawnee	CI 11699	1942	Kansas, Nebraska	Kawvale	3, 6, 9	6, 8, 9	1, 4, 7
Ponca	CI 12128	1951	Kansas	Mql-Kv	2, 3, 5, 6, 7, 9	9	1, 2, 4, 5, 7
Monon	CI 13278	1959	Indiana	W38, H_3			All of Missouri
Omaha	CI 13015	1960	Nebraska	Kawvale	3	2, 3, 5, 6, 8, 9	
Warrior	CI 13109	1960	Nebraska	Kawvale	1, 2	1, 2, 7, 8	
Ottawa	CI 12804	1960	Kansas	W38, H_3	All of Kansas	7, 8, 9	1, 2, 4, 7
Knox 62	CI 13701	1962	Indiana	PI 94587, H_6			All of Missouri
Gage	CI 13532	1963	Nebraska	Mql-Kv	2, 3, 5, 6, 9	1, 5, 6, 7, 8, 9	1, 4, 7
Riley	CI 13270	1965	Indiana	W38, H_3			1, 3, 4
Shawnee ...	CI 14157	1967	Kansas	W38, H_3	All of Kansas	7, 8, 9	1, 2, 4, 5, 7
Ben Hur ...	CI 14054	1966	Indiana	PI 94587			All of Missouri
Parker	CI 13285	1966	Kansas	Mql-Kv	3, 5, 6, 8, 9	8, 9	1, 4, 7
Kerwin	CI 17275	1973	Kansas	Mql-Kv	1, 2, 4, 5, 7, 8	7, 8	

[1]Cereal index identification number.

[2]Wheat variety from which resistance was taken and gene designation when known. Kv = Kawvale, Mql = Marquillo (*4*).

[3]Crop reporting districts shown in figure 2.

TABLE 2.—*Hessian fly infestation percentages in wheat varieties from Kansas, Nebraska, and Missouri, 1971-72 and 1972-73 crop years*

Cultivar	Type of resistance[1]	Kansas		Nebraska		Missouri	
		Fields examined	Culms infested	Fields examined	Culms infested	Fields examined	Culms infested
		Number	*Percent*	*Number*	*Percent*	*Number*	*Percent*
Ottawa	W38, H_3	43	0.5	3	0	16	2.5
Shawnee	W38, H_3	14	.5			3	2.0
Parker	Mwl-Kv	43	.1			14	2.1
Warrior	Kawvale	12	.5	8	0		
Gage	Mql-Kv	9	.7	14	0	4	1.0
Lancer	none	12	2.3	16	.9	1	0
Scout	Marquillo	82	4.2	51	2.5	12	6.8
Bison	none	31	6.3	12	4.1	6	1.3
Triumph	none	102	4.1	14	4.1	3	8.2
Satanta	none	24	16.0				
Chanute	none	8	1.3			1	4.0
Pronto	none	18	2.6			1	0
Danne	none	6	3.4				
Eagle	none	72	7.1				
Apache	none	4	16.0				
Polo Duro	none	1	18.0				
Caprock	none	2	1.0				
Wichita	none	2	5.0				
Sturdy	none	6	.7				
Kaw	none	6	13.0				
Scout 66				25	2.3		
Centurk	none			212	1.5		
Scoutland	none			48	4.7		
Trader	none			6	0		
Trapper	none			4	0		
Guide	none			7	.5		
Cheyenne	none			1	0		
Arthur	none					78	3.5
Monon	W38, H_3					28	5.7
Blueboy	none					4	5.0
Ben Hur	PI 94587, H_6					7	.4
Knox 62	PI 94587, H_6					12	0
Pawnee	Kawvale	7	2.0			1	2.0
Kirwin	Kv-Mql	3	0				
Cloud	none	6	3.0				
Sage	none	2	.7				
Trison	none	1	.3				

[1]Wheat variety from which resistance was taken and gene designation when known. Kv = Kawvale, Mql = Marquillo (*4*).

Control of Hessian Fly

The three most important methods of Hessian fly control include planting resistant varieties, delayed planting to escape fall infestation, and clean cultivation or proper management of volunteer wheat. The Kansas, Nebraska, and Missouri area has several suitable resistant varieties. Table 1 lists wheat varieties that have been developed for this area, their type of resistance, and the suggested area of adaptability for each. Commercial quantities of seed are not available for some of the varieties but they could quickly be increased to meet demand.

Table 2 gives infestation percentages of the various wheat varieties collected in the 1972-73 survey. Late fall plantings escape most of the injury from Hessian fly. The approximate safe

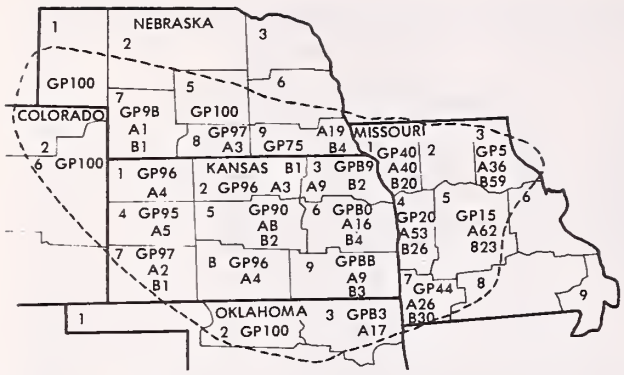

FIGURE 2.—Distribution of Hessian fly races shown by crop reporting districts. A–Race A; GP–Great Plains race; B–Race B.

planting date for central Great Plains is September 25 in the northwest and October 12 in the southeast (2). The safe planting date for any particular locality should be obtained from local experiment stations or county agricultural extension agents. Modern machinery, which enables farmers to plant their crops much more quickly, makes later planting dates a more realistic control measure than was formerly possible.

Cultural practices necessary for the production of certified or registered wheat seed have been effective in reducing Hessian fly infestation. Growers who kept their fields clean and free from weed growth and properly tilled and planted the top quality seed necessary for certified or registered seed production had only half the Hessian fly infestation of random field samples in the same area. Table 3 presents this data for the 1969 to 1973 crop years. Analysis of this data separating the fields into susceptible and resistant wheat varieties shows that, regardless of variety, the properly managed fields had only one-half the infestation of a comparable group of fields from the random collection.

TABLE 3.—*Hessian fly infestations in fields of certified wheat and other wheat fields*

		Certified wheat fields		Other wheat fields	
	Year	Fields examined	Culms infested	Fields examined	Culms infested
		Number	*Percent*	*Number*	*Percent*
Susceptible	1969	227	0.94	181	2.25
wheat	1970	143	.83	93	3.63
varieties	1971	103	1.35	41	4.25
	1972	153	2.41	83	5.03
	1973	96	3.02	41	5.81
Average...			1.71		4.19
Resistant	1969	136	.12	17	.20
wheat	1970	73	.14	21	1.03
varieties	1971	29	.31	39	.78
	1972	18	.28	31	.37
	1973	5	.43	15	1.05
Average...			.25		.68

Hessian Fly Populations Reduced by Using Resistant Wheat Varieties

Observations of the Hessian fly population in Kansas for the past 24 years have indicated that a relatively low percentage of wheat acreage sown to resistant varieties will reduce the Hessian fly population in all wheat fields in the area. An analysis of the survey data from an area in north-central Kansas substantiates that theory. The area, approximately 120 miles long and 115 miles wide, includes 17 counties: Barton, Clay, Cloud, Dickinson, Ellsworth, Jewell, Lincoln, McPherson, Mitchell, Osborne, Ottawa, Republic, Rice, Saline, and Washington (fig. 3). The Great Plains race of fly is predominant in the western half of the area, and a mixture of Great Plains race and race A occurs in the eastern half.

The variability of fly races as well as cropping practices makes changes in fly populations show up immediately in the spring generation. In the northeastern portion of the area, fields are smaller than in the southwestern area, and the corn and sorghum acreages are somewhat larger in the northeast. In the southwest considerable summerfallowing is done. Crop rotations are common and wheat is not generally planted in any field more than 2 years in succession. Those cropping practices keep the Hessian fly population moving from field to field and prevent biological races of fly from becoming isolated in any field.

Wheat varieties have changed rapidly in central Great Plains States because new varieties are accepted readily. In 1934 Kawvale was introduced as a mildly fly resistant variety, but it was never grown on more than a small percentage of the wheat acreage. However, even with low levels of resistance, Kawvale reduced the fly population, as did such cultural practices as destroying volunteer wheat and adhering to recommended fly-free planting dates. Kawvale resistance and

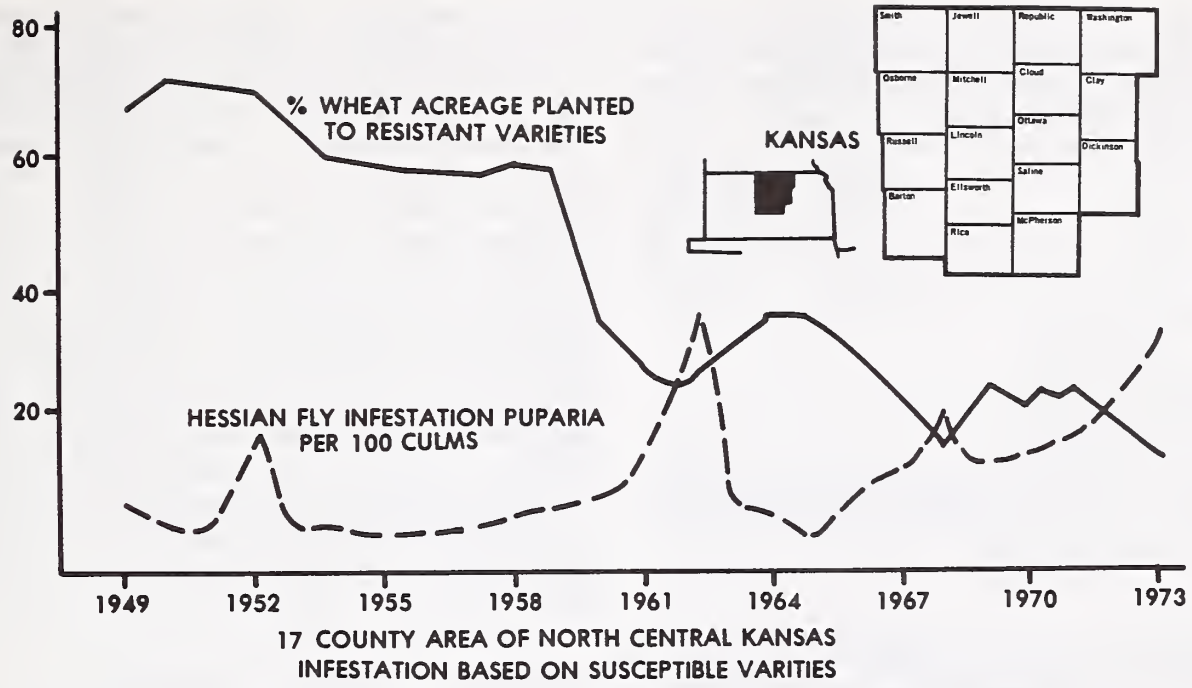

FIGURE 3.—Percentages of wheat acreage planted to Hessian fly resistant wheat varieties compared with maximum Hessian fly infestations 1949 through 1973.

recommended cultural practices reduced wheat losses because of Hessian fly infestation.

The variety Pawnee, released to farmers in 1943, was grown on 24 percent of the wheat acreage of Kansas by 1947, and on 38 percent of the wheat acreage by 1950. It comprised 93 percent of the wheat acreage of Ottawa County and a correspondingly high percentage of the acreage of other counties in the 17-county study area. Ponca was released in 1951. It increased steadily until 1959 then declined rapidly. Pawnee also declined then, which left the area without Hessian fly protection (fig. 3). Fly infestations given (fig. 3) are averages of the highest infestations in susceptible wheats for each of the 17 counties of the area.

Infestations of resistant varieties never exceeded a fraction of 1 percent. Some of those data were reported by Painter (*10*) who observed the control of Hessian fly from 1949 to 1958 then the sharp increase of fly from 1959 to 1962 when acreages of resistant varieties declined. He did not record details on distribution of biotypes of the fly but apparently race A was much more prevalent in the central area of Kansas than it is now.

Figure 3 shows two other periods when Hessian fly populations changed rapidly to coincide with changes in wheat varieties. In 1967 Shawnee was released. Although it comprised only a small percentage of the wheat crop, Shawnee markedly influenced the fly population, even though this variety was relatively short lived and acreage began declining in 1971. The fly population immediately increased. Those data indicated that if approximately 30 percent of the wheat acreage is planted to resistant wheats, they will decidedly suppress the total fly population.

A good example was the 1968-69 crop year, when 12 counties with less than 30 percent resistant varieties had almost three times the infestation as in the other 5 counties of the area where resistant varieties exceeded 50 percent (table 4). The 1968-69 crop year was selected because a thorough survey was made that spring. Infestations were based on the average of the three highest infestations from each of the 17 counties in the area.

Luginbill (*7*) proposed rotating 3 years of susceptible wheat then 2 years of resistant wheat to control the wheat stem sawfly. The sawfly is a univoltine insect, whereas the Hessian fly usually has two or more broods during the year; the Hessian fly is somewhat more difficult to control. However, a rotation of 2 years resistant wheat

TABLE 4.—*Hessian fly infestations in counties with less than 30 percent resistant wheat and counties with more than 30 percent of their wheat acreage in resistant varieties*

	Wheat acreage in resistant varieties	Maximum[1] Hessian fly infestation
	Percent	*Percent*
12 counties with less than 30 percent resistant wheat	14	34
5 counties with more than 30 percent resistant wheat	46	13

[1]Maximum Hessian fly infestation calculated by selecting three highest infestations in susceptible varieties for each county in the area.

followed by 2 years of susceptible wheat should keep Hessian fly damage below economic levels.

Methods

Determination of races.—Hessian fly races are distinguishable by their ability or inability to infest certain wheat varieties. Five wheat varieties, one completely susceptible, and the others with a single gene each for resistance can be used to differentiate at least eight races of the Hessian fly (*5*). As only three races of the fly were present in the study area, only three differential wheat varieties were needed to separate races of flies. Varities used were Triumph, which is susceptible to all races of the fly; Seneca, which resists the Great Plains (GP) race but is susceptible to races A and B; and Shawnee, which is susceptible to race B flies but resistant to races GP and A. Part of the time Knox 62 was used as a resistant check.

Four or five seeds of each wheat variety were planted in 4-inch pots. At the two- or three-leaf seedling stage, individual female Hessian flies were caged on each pot by placing a 6-inch plant stake in each corner of the pot, draping an 18-inch square of cheesecloth over the stakes, and tying the edges around the pot. Hessian flies are strongly phototrophic and will seldom try to crawl downward under a cloth's edge. The plants were kept covered from 8 to 10 days and then examined for larvae. Larvae were usually in the second instar on susceptible wheats and could be seen as small red larval remains on resistant plants.

To check the possibility that small percentages of races C and D were not present in the collections, the flies that were not individually isolated were caged enmass on pots containing all four differential wheat varieties.

Testing flies came from either the samples collected in the spring infestation-and-loss survey or from field collections specifically gathered for this study. Survey samples gave a much wider coverage and had the advantage of coming from a known wheat variety, but numbers were usually small and difficult to work with. Increasing the flies one generation in the greenhouse was often necessary to obtain sufficient numbers for testing.

Increasing the flies in the greenhouse did not seem to alter the ratio of the various races in the sample.

Abundance, distribution and loss surveys

Methods used to determine Hessian fly abundance and loss have been developed by researchers over many years. These methods are not comprehensive enough to determine loss in any small area but have been consistent for the past several years to give a good comparison of infestation and loss from year to year.

Spring infestation has been based on a 50-culm sample from each field. The 50 culms are collected from 5 or more plants which are at least 10 feet apart. Each culm is examined carefully. The leaf sheaths are removed from the large culms and the small ones are dissected to look for Hessian fly puparia (flaxseed).

A deficiency in such a survey is that flaxseeds are much more visible on tolerant or semiresistant plants than on fully susceptible ones. Stems of tolerant plants are strong enough to keep the flaxseed in place where it can be found; stems of susceptible plants often are so weakened that they break and the flaxseed falls out. Also tillers of susceptible plants may die when small and not be noticed at harvesttime, so the full extent of infestation in susceptible varieties is difficult to determine. Resistant or tolerant varieties may appear to be more heavily infested than susceptible varieties collected at the same time.

Summary

Producers and researchers often disregard the long term benefits of low levels of resistance and farming practices that reduce, but may not completely control, insect and disease incidence. Such control measures may be disregarded either because varieties with low resistance are not recommended or available or because proper cultural practices are not followed. Whatever the reason, agricultural production is needlessly lost.

The long term or accumulative effects of using varieties with low resistance and small percentages of resistant varieties are illustrated in the data presented here. Intensive survey records have been maintained in the 17-county area of Kansas, where Hessian fly infestations were consistently severe before the variety Pawnee was released. Evidently about 30 percent of the wheat acreage planted to resistant varieties reduced Hessian fly infestation over the entire area.

Cultural practices recommended for production of certified and registered seed will reduce Hessian fly incidence by one-half regardless of variety of wheat grown. These producers keep their fields free of volunteer wheat or grass hosts, plant after the Hessian fly-free date, and in general use cultural practices recommended for efficient wheat production.

Three major biotypes or races of the Hessian fly are found in Kansas, Nebraska, and Missouri. The Great Plains race predominates in Kansas and Nebraska. Race A predominates in Missouri. These two predominant races are avirulent. Wheats with low resistance will give adequate protection from both races. Use of wheats with low resistance has not promoted the development of more virulent races. *Therefore, incorporating low resistance into all wheat grown is more important than developing a single variety with strong resistance.*

One wheat variety with strong resistance grown over a wide area will increase more virulent Hessian fly races by the mechanism of selective pressure. That occurred on a north-central Kansas farm where almost the entire wheat acreage was Ottawa and Shawnee for several successive years. The selective pressure of those two varieties, which have the single H_3 gene for resistance, increased race B flies, which are able to infest both Ottawa and Shawnee. Although some infestation existed in wheat varieties with H_3 gene for resistance, it was so light that yield losses were not economically important. Several more years would be needed to develop a purified population of race B flies in the field.

Although continued intensive research on breeding resistant wheat is needed, more emphasis should be placed on practicing control measures to significantly reduce Hessian fly infestation and losses.

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